Comparison of sinusoidal vision trifocal intraocular lens with monofocal extended depth of focus intraocular lens after cataract surgery

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ABSTRACT

Purpose: To evaluate and compare the clinical results of sinusoidal vision trifocal intraocular lens (IOL) (Acriva[UD] Trinova) and monofocal extended depth of focus (EDOF) IOL (Tecnis Eyhance ICB00)

Materials and Methods: This study included 98 eyes of 65 patients implanted with sinusoidal vision trifocal IOL and 79 eyes of 53 patients implanted with monofocal EDOF IOL. The following were evaluated; Uncorrected and corrected distance (UDVA, CDVA), intermediate (UIVA, CIVA), near visual acuity (UNVA, CNVA), halo, glare, ocular aberrations, contrast sensitivity, capsule opacification. In addition, The National Eye Institute 25-Item Visual Function Questionnaire (NEI-VFQ 25) results were analysed.

Results: Three months postoperatively, there were no differences between the groups in terms of UDVA and UIVA (respectively, p=0.780 and p=0.317). Near vision was found to be better for the Trinova group than for the Eyhance group (p<0.001). Eyhance IOL provided better contrast sensitivity at all spatial frequencies than Trinova IOL (p<0,001). Halo perception was reported for only six eyes, all of which were in the Trinova group (6.9%). Glare perception was found to be more common in the Trinova group (15 eyes (17.2%)), than in the Eyhance group (four eyes (5.3%)). With regard to the composite score of NEI-VFQ 25, no significant difference was found between the groups (p=0.201). In the analyses of subgroups, the near activities score was higher in the Trinova group, but distance activities and driving scores were higher in the Eyhance group (p<0,05).

Conclusion: Both lenses have been shown to have satisfactory levels of distance and intermediate vision, with high levels of patient satisfaction. Considering their advantages over each other, IOL preferences should be made according to the priorities of the patients.

Keywords: Cataract, contrast sensitivity, glare, multifocal intraocular lenses.

INTRODUCTION

The predictability of surgical outcomes and the expectations of patients have increased with improvements in cataract surgery techniques. Conventional monofocal intraocular lenses provide satisfactory distance vision. However, spectacle dependency for near vision affects patients' quality of life and satisfaction. Therefore, different intraocular lens designs that can provide spectacle-free vision from distance to near have been developed. Bifocal and trifocal lens designs, the most prominent of these lens designs, have disadvantages such as halo, glare complaints and decreased contrast sensitivity[1], which are the leading causes of dissatisfaction after multifocal IOL implantation.[2] Unlike these IOLs, monofocal EDOF design promises an increase in intermediate distance vision and fewer subjective visual complaints. Monofocal EDOF IOLs can provide adequate intermediate distance vision with a high quality distance vision due to the extended depth of focus, asphericity and pinhole optic.[3] However, studies with monofocal EDOF IOLs have shown that they do not provide sufficient near vision as multifocal IOLs do.[4] The newly available sinusoidal diffractive trifocal

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IOLs are designed with stepless waves, unlike the other trifocal IOLs, promises higher light transfer to the retina, wider focal depth, more continuous light distribution, less chromatic aberrations and fewer photopsy complaints.[5] Both novel lens designs aim to provide a continuous vision with less subjective visual complaints.[6] As far as we know, Acriva^{UD} Trinova (VSY Biotechnology, The Netherlands) is the first commercially available IOL designed with sinusoidal diffractive profile. Similarly, Tecnis Eyhance ICB00 (Johnson & Johnson Vision Care, Inc.) is the first commercially available EDOF IOL with monofocal design in Turkey. To our knowledge, there is no study comparing the visual acuity, halo glare complaints, contrast sensitivity, and quality of life of patients with sinusoidal vision trifocal IOL or monofocal EDOF IOL. For this purpose, we aimed to compare the clinical results of both lenses mentioned above.

MATERIALS AND METHODS

The data of all patients who underwent cataract surgery between January 2019 and March 2020 with a sinusoidal vision trifocal diffractive IOL or monofocal EDOF IOL implantation were evaluated. Informed consent was obtained from all patients in accordance with International Declaration of Helsinki. Permission and approval were obtained from Erciyes University Faculty of Medicine Clinical Research Ethics Committee with the decision numbered 2020/96681246

The study included 98 eyes of 65 patients implanted with a sinusoidal vision trifocal IOL ((Acriva^{UD} Trinova (VSY Biotechnology, The Netherlands)) and 79 eyes of 53 patients implanted with a monofocal EDOF IOL ((Tecnis Eyhance ICB00 (Johnson & Johnson Vision Care, Inc.)).

Exclusion criteria were keratoconus disease, corneal scarring, uveitis, diabetic retinopathy, hypertansive retinopathy, optic neuropathy, amblyopia. Patients with collagen tissue diseases, diabetes, hypertension, and other systemic conditions that potentially affect the eyes were excluded from the study. Patients with intraoperative or postoperative complications were also excluded from the sudy.

Preoperative evaluation

Demographic data of the patients such as age and gender were recorded. Uncorrected distance (4 m) (UDVA), intermediate (67 cm) (UIVA), near (35cm) visual acuity (UNVA), corrected distance (CDVA), intermediate (CIVA), near (CNVA) visual acuity were recorded with the Early Treatment Diabetic Retinopathy Study (ETDRS) chart. Contrast sensitivity levels at 1.5, 3,6,12,18 gratings were measured by CSV 1000E test (ClearChart 2 Digital Acuity System (Reichert Technologies)).

Post-operative evaluation

All patients were examined at first day, first week, first month and third months postoperatively. The following were evaluated: UDVA, UIVA, UNVA, CDVA, CIVA, CNVA, spectacle dependency, halo, glare, ocular aberrations (iDesign (Abbott Medical Optics, Inc., Santa Ana, CA, USA)), contrast sensitivity. The National Eye Institute 25-Item Visual Function Questionnaire (NEI-VFQ 25) results of patients were also analysed. The NEI-VFQ-25 consists of 25 core items that assess 12 different aspects of vision function. The NEI-VFQ-25 subscales and overall scores were calculated using the standard algorithm for scoring. Responses were converted to a scale 0 to 100, with higher scores indicating better quality of life. The scores for each of the 12 subscales were calculated by averaging the items within that subscale, and the average scores of all 25 items were used to determine the NEI-VFQ-25's overall score.[7]

Statistical analysis

The normality of data was assessed using the Shapiro Wilks test, Kolmogorov Smirnov test and histogram graphics. Two independent samples test was used to compare normally distributed groups. Mann Whitney U test was used to compare groups that did not conform to normal distribution. In comparison of the values at different measurement times, Wilcoxon test was used when the number of groups was two, and Friedman's test was used when the number of groups was three or more. Pearson Chi-Square and Pearson's Exact Chi-Square analyzes were used in cross-table analysis. IBM SPSS Statistics 22.0 (New York, USA) program was used in the implementation of all these analyzes. P <0.05 value was accepted as the criterion for statistical significance.

RESULTS

Demographic and preoperative clinical characteristics of eyes included in the study were given in Table 1. All patients were implanted with emmetropic target. Three months postoperatively, refractive values and comparison of the groups were given in Table 2. In the Trinova group, mean spherical and spherical equivalent values were found to be more myopic (respectively, p=0.01 and p=0.001). There was no difference between the two groups in terms of cylindrical values (p=0.906).

Table 1: *Demographic and preoperative clinical characteristics of eyes included in the study*				
		Acriva Trinova (n:87)	Eyhance ICB00 (n:75)	P* value
Sex	Female (%)	37(42.5%)	41(45.3%)	0,123
	Male (%)	50(57.5%)	34(54.7%)	
Laterality	Right eye	48(55,2%)	40(53,3%)	0,815
	Left eye	39(44,8%)	35(46,7%)	
Age (Mean ± SD)		54,12 ± 9,97	56,92 ± 11,66	0,076
Axial length (Mean ± SD)		23,69±1,30	23,83±1,45	0,937
Spheric equivalents,D (Mean ± SD)		-0,14 ± 0,77	-0,62 ± 0,90	0,556
UDVA (logMAR) (Mean ± SD)		0,89 ± 0,37	0,90 ± 0,04	0,732
CDVA (logMAR) (Mean ± SD)		0,78 ± 0,04	0,74 ± 0,04	0,559
UIVA (logMAR) (Mean ± SD)		0,72 ± 0,23	0,77 ± 0,23	0,138
UNVA (logMAR) (Mean ± SD)		0,68 ± 0,27	0,80 ± 0,22	0,071

Abbreviation: D.dioptre ; SD, Standard Deviation ; logMAR,Logarithm of the minimum angle of resolution ; UDVA,Uncorrected distance visual acuity; UIVA;Uncorrected intermediate visual acuity; UNVA,Uncorrected near visual acuity

Table 2: *Comparison of the postoperative third month refractive outcomes of the eyes included in the study*			
	Acriva Trinova (n:87)	Eyhance ICB00 (n:75)	P* value
Sphere,D			
Mean ± SD	-0,47 ± 0,52	-0,24 ± 0,46	
Median	-0,50	-0,25	**0,01**
Min/Max	-1,75 / 0,75	-2,00 / 0,75	
Cylinder,D			
Mean ± SD	-0,72 ± 0,38	-0,75 ± 0,51	
Median	-0,75	-0,75	0,906
Min/Max	-1,50 / 0,75	-2,75/ 0,75	
Spherical equivalents,D			
Mean ± SD	-0,84 ± 0,55	-0,61 ± 0,44	
Median	-0,87	-0,62	**0,001**
Min/Max	-2,38 / 1,13	-2,38/ 0,25	
UDVA,logMAR			
Mean ± SD	0,08 ±0,08	0,09 ± 0,08	0,780
Median	0,1	0,1	
CDVA,logMAR			
Mean ± SD	0,04±0,06	0,01±0,03	<0,001
Median	0,0	0,0	
UIVA,logMAR			
Mean ± SD	0,17±0,10	0,15±0,10	0,317
Median	0,2	0,1	
CIVA,logMAR			
Mean ± SD	0,06±0,07	0,01±0,03	<0,001
Median	0,0	0,0	
UNVA,logMAR			
Mean ± SD	0,09±0,08	0,25±0,12	<0,001
Median	0,1	0,2	
CNVA,logMAR			
Mean ± SD	0,03±0,05	0,01±0,03	0,034
Median	0,0	0,0	

**Mann-Whitney U testi*

Abbreviation: D.dioptre ; SD, Standard Deviation ; logMAR,Logarithm of the minimum angle of resolution ; UDVA,Uncorrected distance visual acuity ; CDVA,Corrected distance visual acuity;UIVA;Uncorrected intermediate visual acuity;CIVA,Corrected intermediate visual acuity;UNVA,Uncorrected near visual acuity;CNVA,Corrected near visual acuity

Visual acuity

At the end of the third months after surgery, statistically significant increase in visual acuity at all distances in both groups was detected. (p<0.001) (Friedman test). Regarding uncorrected visual acuities, both IOL groups had satisfactory UDVA and UIVA, without statistically significant differences between groups (p=0.759 and p=0.295, respectively). There was a statistically significant difference between UNVA distributions between the groups (p<0.001) (Chi-squared test). In the Trinova group, UNVA was 0.0 logMAR in 27 eyes (31.4%) and 0.1 logMAR in 44 eyes (51.2%). In the Eyhance group, only for four eyes (5.3%) UNVA was 0.0 logMAR and 0.1 logMAR for nine eyes (12%) (Figure 1). Uncorrected near vision was better in the Trinova group(p<0.001) (Mann Whitney test).

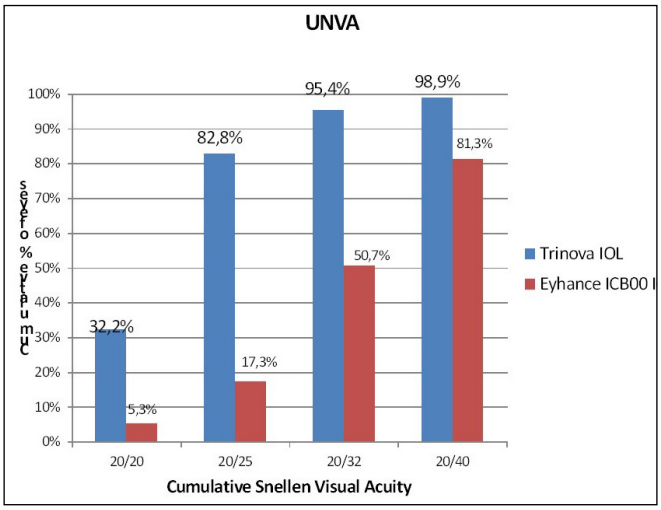

Figure 1: *Cumulative distribution of uncorrected (UNVA) near visual acuity for two intraocular lenses: (A) Acriva^{UD} Trinova (VSY Biotechnology, The Netherlands), (B) Tecnis Eyhance ICB00 (Johnson & Johnson Vision Care, Inc.)*

Contrast sensitivity

Contrast sensitivity were found to be decreased for the Trinova group than the Eyhance group at all spatial frequencies(p<0,001) (Table 3).

Aberration

There was no significant difference between the two groups in high-order, primary coma and trefoil aberrations (p=0.052; p=0.245; p=0.295, respectively). Primary spherical aberrations and total aberrations were found to be higher in the Trinova group than the Eyhance group (Table 4) (p<0.001 for both groups).

Photic Phenomena

Halo perception was reported for only six eyes, all of which were in the Trinova group (6.9%). Glare perception was found to be more common in the Trinova group, where it occured in 15 eyes (17.2%), than in the Eyhance group, where it occured in four eyes (5.3%) (p<0,05). However, dysphotopsy was similar in both groups(p=0,516).

The National Eye Institute 25-Item Visual Function Questionnaire

While general health and near activities scores were higher in the Trinova group, distance activities and driving scores were found to be higher in the Eyhance group (p=0.005; p=0.001; p<0.001; p=0,001, respectively). Overall

Table 3: *Contrast sensitivity results three months postoperatively*

Contrast sensitivity test	Acriva Trinova	Eyhance ICB00	*P value
1,5 cpd			
Mean ± SD	1,36 ± 0,11	1,43 ± 0,14	
Median(min-max)	1,39(1,09-1,60)	1,49(1,20-1,60)	**<0,001**
3 cpd			
Mean ± SD	1,45 ± 0,12	1,52 ± 0,10	
Median(min-max)	1,49(1,20-1,60)	1,60(1,20-1,60)	**<0,001**
6 cpd			
Mean ± SD	1,35 ± 0,16	1,49 ± 0,13	
Median(min-max)	1,30(1,09-1,60)	1,49(1,00-1,60)	**<0,001**
12 cpd			
Mean ± SD	1,00 ± 0,18	1,17 ± 0,12	
Median(min-max)	1,39(0,49-1,39)	1,20(1,09-1,30)	**<0,001**
18 cpd			
Mean ± SD	0,59 ± 0,23	0,87 ± 0,09	
Median(min-max)	0,60(0-1,09)	0,90(0,69-1,00)	**<0,001**

Abbreviations: SD, standart deviation; cpd, *Mann-Whitney U testi, min-max: minimum-maximum

Table 4: *Comparison chart of idesign wavefront aberrations at the third month postoperatively*			
	Trinova IOL (n=43)	Eyhance ICB00 IOL (n=34)	P value
High order aberration (µ)			
Mean ± SD	0,31 ± 0,16	0,26 ± 0,21	
Median	0,28	0,22	0,052
Min/Max	0,11 / 0,90	0,08 / 1,17	
Primary coma aberration (µ)			
Mean ± SD	0,09 ± 0,06	0,07 ± 0,05	
Median	0,08	0,06	0,245
Min/Max	0,02 / 0,26	0,01 / 0,23	
Primary Trefoil aberration (µ)			
Mean ± SD	0,11 ± 0,06	0,10 ± 0,05	0,295
Median	0,11	0,09	
Min/Max	0,01 / 0,25	0,01 / 0,25	
Primary spherical aberration (µ)			
Mean ± SD	0,06 ± 0,02	-0,01 ± 0,03	**<0,001**
Median	0,06	-0,02	
Min/Max	-0,02 / 0,11	-0,07 / 0,06	
Total aberration (µ)			
Mean ± SD	0,83 ± 0,30	0,59 ± 0,30	
Median	0,78	0,57	**<0,001**
Min/Max	0,42 / 1,77	0,20 / 1,61	
Abbreviations: SD: standart deviation, D: dioptre, (µ): Value in RMS (Root Mean Square, Root Mean Square). *Mann-Whitney U testi, min-max: minimum-maximum			

composite score averages were 92,32 ± 8,36 in the Trinova group, 94.74 ±4.79 in the Eyhance group. There was no statistically significant superiority between the two groups (p=0.201). It was given in detail in Table 5.

Posterior capsule opacification

It was found that 11 eyes (11.2%) in the Trinova group and four eyes (5.1%) in the Eyhance group had posterior capsule opacifications within a three months period. The rate of posterior capsule opacification (PCO) was not different statistically between the two groups (p=0.233).

DISCUSSION

Because of advances in cataract surgery, better and more predictable outcomes are observed. This has led to an increases in patients' expectations such as for achieving better intermediate and near vision and to patients having fewer subjective visual complaints.[8] With EDOF lens technology, a single elongated focal point is obtained to enhance range of vision resulting with better intermediate vision.[9,10] The newly available sinusoidal vision trifocal IOL's promise continuous vision at all distances with no sharp transitions between foci.[5] Therefore, we compared the clinical results of these two lenses, which have different novel designs.

In our study, UNVA was higher in the trinova group, and CDVA, CIVA and CNVA were higher in the eyhance group. The contrast sensitivity was better in the Eyhance group than in the Trinova group. There were fewer complaints about halo and glare perceptions in the Eyhance group. In addition, the mean NEI-VFQ-25 overall composite scores of both groups were found to be similar. However, distance activities scores and vision-specific driving scores were higher in the eyhance group.

Studies have shown that premium IOLs provide better intermediate or near vision, without significant sacrifices to distance vision.[11-13] In the present study, we also found the distance visual acuity of the patients to be sufficient and have good levels of quality. No statistically significant superiority was found between the groups in terms of UDVA values (p> 0.05).

In the study of Mencucci et al., the mean uncorrected visual acuity at a distance of 80 cm at mesopic conditions were 0.19 ± 0.11 logmar, 0.38 ± 0.08 logmar and 0.29 ± 0.13 logmar in the patients implanted with Tecnis Symfony ZXR00 IOL (Abbott Medical Optics, Inc., Abbott Park, IL), which is a bifocal diffractive EDOF lens, PanOptix IOL(Alcon Laboratories, Fort Worth, TX, USA) and AT LISA tri839MP IOL(Carl Zeiss Meditec, Jena, Germany)

Table 5: *Postoperative third month NEI-VFQ-25 Visual Function Scale results and subgroup analyzes of the patients*

	Acriva Trinova	Eyhance ICB00	P value*
General health Mean ± SD Median(min-max)	77,72 ± 21,87 75(25-100)	66,00 ± 22,45 75(25-100)	**0,005**
General vision Mean ± SD Median(min-max)	76,00 ± 14,60 80(40-100)	78,40 ± 12,67 80(60-100)	0,441
Ocular pain Mean ± SD Median(min-max)	84,77 ± 15,34 87,50(37,50-100)	85,25 ± 15,50 87,50(50-100)	0,303
Near vision Mean ± SD Median(min-max)	93,56 ± 8,74 100(66,67-100)	87,50 ± 9,99 91,66(50-100)	**0,001**
Distance vision Mean ± SD Median(min-max)	91,21± 9,13 91,66(50-100)	96,33 ± 7,60 100(66,67-100)	**<0,001**
Role limitations Mean ± SD Median(min-max)	95,90 ± 9,01 100(62,5-100)	93,75 ± 10,48 100(62,5-100)	0,421
Driving Mean ± SD Median(min-max)	85,08 ± 15,20 100(75-100)	87,28 ± 15,13 100(75-100)	**0,001**
Vision spesific dependency Mean ± SD Median(min-max)	99,84 ± 1,12 100(91,67-100)	99,83 ± 1,17 100(91,67-100)	0,980
Vision spesific social function Mean ± SD Median(min-max)	99,09 ± 4,06 100(75-100)	99,75 ± 1,76 100(87,5-100)	0,353
Vision spesific mental health Mean ± SD Median(min-max)	96,47 ± 4,29 100(87,5-100)	95,75 ± 6,11 93,75(62,5-100)	0,747
Colour vision Mean ± SD Median(min-max)	96,36 ± 12,18 100(50-100)	99,50 ± 3,53 100(75-100)	0,114
Peripheral vision Mean ± SD Median(min-max)	98,18 ± 6,55 100(75-100)	98,50 ± 5,99 100(75-100)	0,797
Composite score Mean ± SD Median(min-max)	92,32 ± 8,36 93,92(41,67-100)	94,34 ± 4,79 95,34(72,67-100)	0,201

min-max: minimum-maximum

respectively (p <0.001).[13] In another study conducted by Mencucci et al., statistically significant improvement of intermediate visual acuity was reported (0.28 vs 0.40 logMAR in monocular UIVA) at the sixth month following Tecnis Eyhance ICB00 (Johnson &Johnson Vision) implantation.[10] Similarly, in a study by Lopes et al. examining Eyhance IOL, the mean UIVA was significantly better in the Eyhance group compared with the monofocal group, both for monocular UIVA (0.21 vs 0.30 logMAR, p<0.001) and for binocular UIVA (0.17 vs 0.30 logMAR, p<0.001).[14] In a recently published study examining Trinova IOL, Kılıç et al. reported a mean UIVA of 0.2 ± 0.10 logMAR over 3 month follow-up.[15] In agreement with these studies, intermediate visual acuities in our study were satisfactory in both groups. The mean UIVAs were 0.16 ± 0.10 (median:0.2) logMAR and 0.14 ± 0.10

(median:0.1) logMAR in the Trinova group and Eyhance group respectively. No statistically significant difference was found between the groups (p>0.05).

In the study that Pan-pan Ye et al. conducted on a diffractive lens, Tecnis ZM 900 IOL(Abbott Medical Optics, Inc., Abbott Park, IL), better visual acuities (p<0.001) were observed at distances of 30 cm and 40 cm compared to the monofocal IOL.[16] The results of our study are similar to this study, since the mean visual acuity at a distance of 35 cm was found to be 0.09 ± 0.08 logMAR (median:0.1 logMAR), which represents a satisfactory level in the Trinova group, which is a diffractive IOL. However, Kılıç et al. compared the clinical results of PanOptix IOL(Alcon, Fort Worth, TX, USA) and Trinova IOL and found that PanOptix IOL showed better near and indermediate visual acuities.[15] Given the UNVA values after Trinova IOL implantation, our results demonstrated a lower mean UNVA (0.09 vs 0.2 logMAR).

Optic surface profile of Trinova IOL differs from conventional trifocal designs in that it contains stepless waves (Figure 2). This design promises more continuous and even light distribution to all focal points. However, this design might make objective refractive outcomes more difficult to determine. In our study, all patients were implanted with emmetropic target. We found that the mean spherical equivalents in the Trinova group were -0,84 ± 0,55 D (median: -0.87). One of the limitation of our study is that we did not evaluate defocus curve. According to the study of Uçar et al., the autorefractometer measurements in Trinova group were not consistent with subjective refraction. They reported that the mean postoperative 12th month spherical equivalent was -1.12± 0.18 (-0.50-1.50) D (objective measurement) and -0.24 ± 0.41 (-0.75-0.50) D (subjective measurement).[17] Based on these results, we speculate that the results in our study represent the best IOL performance for Trinova IOL. However, further studies are needed to confirm this findings.

According to the study by Mencucci et al., mean monocular UNVA at a distance of 40 cm were 0.46 ± 0.13 logMAR in Tecnis Eyhance group, while this was 0.50 ± 0.04 logMAR in the monofocal group (p=0.590). Kang et al. conducted a comparative study of the Tecnis Eyhance IOL with the Tecnis monofocal ZCB00 IOL, obtaining mean postoperative UNVA values of 0.46 ± 0.14 and 0.51 ± 0.19 logMAR, respectively. In our study, UNVA at a distance of 33cm was 0.25 ± 0.11 (median: 0.2) logMAR in Eyhance group.[10] We found better results for near vision than those reported in the studies evaluating the same IOL model,

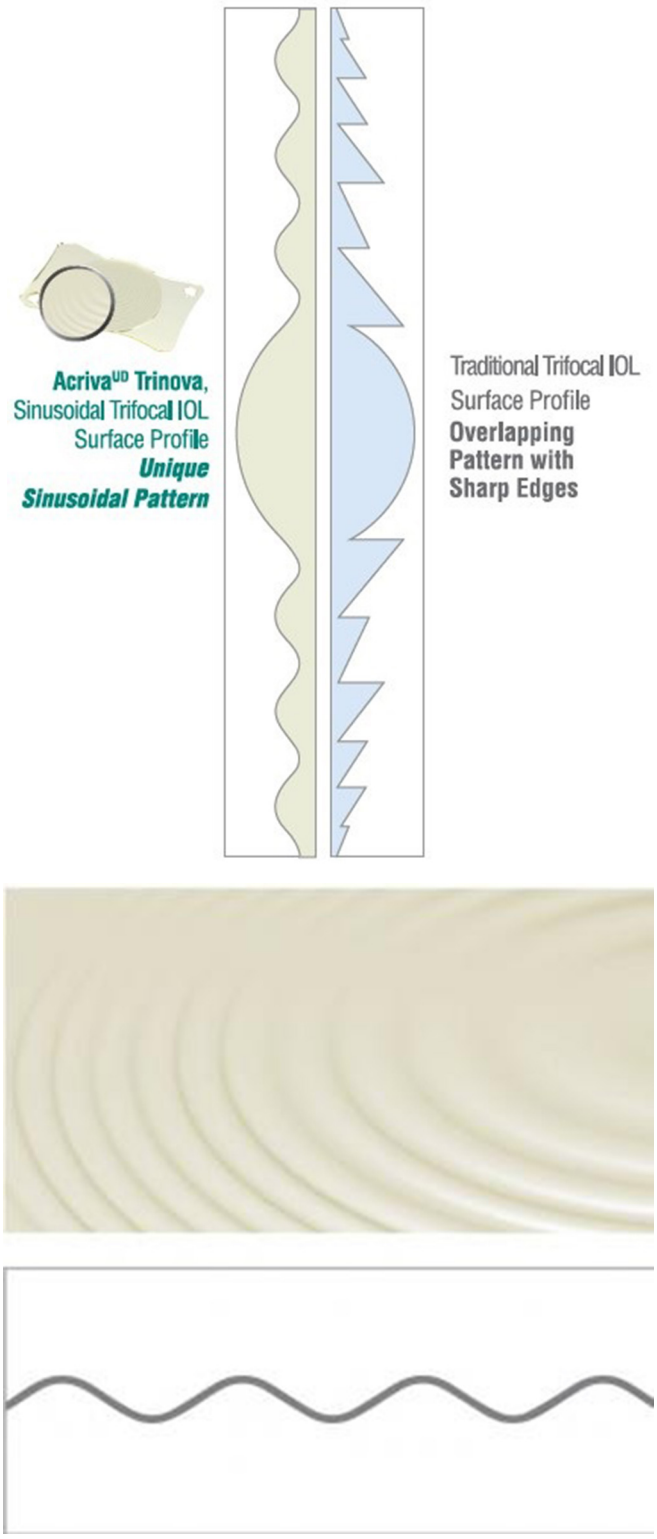

Figure 2: *Stepless diffractive profile of Trinova IOL*

which may be explained by the difference in spherical equivalent values. In our study, the mean spherical equivalents in the Eyhance group (-0.61 ± 0.44 D) were found to be more myopic than the values reported in the study by Mencucci et al (-0.33±0.49 D). Regarding this situation, Cochener et al. examined patients implanted with Tecnis Symfony in two different subgroups. While those

with a target refractive value of 0.50 to 0.75 D myopia were considered as micromonovision group, the other group targeted for emmetropia was called nonmonovision group. Better intermediate and near vision were reported in the micromonovision group without difference in CDVA and UDVA (p=0.003, p=0.011, p=0.485, p=0.853 respectively).[4]

It is known that the level of contrast sensitivity affects the visual functions and daily activities of patients.[18] It has been shown in many studies that there may be a decrease in contrast sensitivity, especially at night, due to the splitting of light in patients implanted with multifocal intraocular lenses. However, the differences between results or the use of different tests make it difficult to evaluate the contrast sensitivity of patients.[19-22] In our study, we also found that contrast sensitivity values in the Trinova group were to be lower than the Eyhance group in all cycles/degrees. A positive correlation between visual acuity and contrast sensitivity values has been shown in previous studies.[23] Considering this correlation, we performed the contrast sensitivity test with spectacles for vision correction. The statistical difference in corrected visual acuity values might have contributed to these significant large differences in contrast sensitivity values.

The effect of the IOL design on aberrations was reported by Holladay et al.[24] Since the Trinova IOL is a diffractive IOL, more aberrations would be expected. However, no statistically significant difference was found between the two groups in terms of aberration parameters, except for spherical aberrations. This might be attributed to the sinusoidal design of the Trinova IOL, which consists of stepless zones and reduces scattered light. The aspheric design of the two lenses that we evaluated in our study minimizes spherical aberrations. The difference in spherical aberrations is probably due to the Trinova group being more myopic in terms of the spherical equivalent mean.

In the study of Chiam et al., moderate glare was observed in 21.3% of eyes implanted with Acrysof ReSTOR IOL and 7.5% of eyes implanted with monofocal Acrysoft A60AT IOL. While there were complaints of halo in 16 (16.3%) eyes with Acrysof ReSTOR IOL, halos were reported in two eyes with (3.8%) monofocal IOL.[25] In the study of trifocal IOLs, including FineVision (PhysIOL SA, Liège, Belgium) and PanOptix IOL, halos were reported in 60% of the patients, even though at different degrees.[26] As a result of its sinusoidal design, Trinova IOL is expected to reduce chromatic aberrations and halo and glare complaints. Consistent with this, we also found that only six (6.9%) eyes included in our study had halo complaints. Halo complaints did not seriously affect quality of life in any of the patients.

Apart from objective strict parameters, we evaluated the visual quality of life of patients with NEI-VFQ-25. Activity scores related to near vision were found to be statistically significantly higher in the Trinova group. We found that the vision-specific driving score was lower in the Trinova group than in the Eyhance group. This can be explained by the higher incidence of photic complaints. Choi et al. compared Eyhance IOL with monofocal IOL and determined the both groups showed improvement in all postoperative questionnaires, attributing this to excellent results in terms of photic phenomena.[27] In agreement with this, we also have reported that those with glare in the Trinova group were statistically lower in driving scores. Although visual acuity tests have a very important place, other factors are also important in evaluating visual quality. Whereas UDVA was similar between the two groups, the distance vision related activities score was higher in the Eyhance group. This difference might be associated with the higher incidence of glare and halo complaints in the Trinova IOL. Additionally, the fact that we did not evaluate the visual acuities in dim environment might be one of the reasons for different results about distance vision.

Our study results showed higher rate of PCO with no statistically significant difference in Trinova group than in Eyhance group, probably due to the lens material. While the Trinova IOL is a hydrophilic lens with a hydrophobic surface, the Eyhance IOL is a hydrophobic lens. It has been postulated that hydrophobic lenses have lower PCO rates than hydrophilic lenses.[28-30] In addition, the haptic design of the two lenses compared in our study is not the same. Hovewer, the effect of haptic design on capsule opacification is controversial. In their study, Prinz et al. reported no statistical difference in terms of PCO scores between plate haptic and open-loop haptic design.[31] In the study conducted by Duran et al., no significant difference was observed in terms of PCO between single-piece acrylic hydrophobic lenses and 3-piece acrylic hydrophobic lenses.[32] Hirnschall et al. found the plate haptic design and the 3-piece open-loop haptic design to be similar in terms of PCO scores.[33] In brief, we consider that follow-up time in our study was too short for the results regarding PCO to be meaningful. For more accurate results, further studies with a larger sample size and longer follow-up period is required.

CONCLUSION

In conclusion, patient selection and patient preferences are very important for these new generation intraocular lenses. Considering the clinical results of other diffractive lenses, photic phenomena in the Trinova group were found to be considerably less than expected. Nevertheless, based on our study data, it should be noted that nighttime visual disturbances and halo, glare perception may occur after Trinova IOL implantation. Subjective visual complaints were reported by fewer patients in the Eyhance group. Both lenses contain promising features that can respond to patients' different demands and expectations.

REFERENCES

1. Leyland M, Zinicola E. Multifocal versus monofocal intraocular lenses in cataract surgery: a systematic review. Ophthalmology 2003;110:1789-98. https://doi.org/10.1016/S0161-6420(03)00722-X
2. de Vries NE, Webers CA, Touwslager WR, et al. Dissatisfaction after implantation of multifocal intraocular lenses. J Cataract Refract Surg 2011;37:859-65. https://doi.org/10.1016/j.jcrs.2010.11.032
3. Kanclerz P, Toto F, Grzybowski A, et al. Extended depth-of-field intraocular lenses: an update. Asia Pac J Ophthalmol (Phila) 2020;9:194-202. https://doi.org/10.1097/APO.0000000000000296
4. Cochener B, Boutillier G, Lamard M, et al. A comparative evaluation of a new generation of diffractive trifocal and extended depth of focus intraocular lenses. J Refract Surg 2018;34:507-14. https://doi.org/10.3928/1081597X-20180530-02
5. Vega F, Valentino M, Rigato F, et al. Optical design and performance of a trifocal sinusoidal diffractive intraocular lens. Biomed Opt Express 2021;12:3338-51. https://doi.org/10.1364/BOE.421942
6. Auffarth GU, Gerl M, Tsai L, et al. Clinical evaluation of a new monofocal IOL with enhanced intermediate function in patients with cataract. J Cataract Refract Surg 2021;47:184-91. https://doi.org/10.1097/j.jcrs.0000000000000399
7. Mangione CM, Lee PP, Pitts J, et al. Psychometric properties of the National Eye Institute Visual Function Questionnaire (NEI-VFQ). NEI-VFQ Field Test Investigators. Arch Ophthalmol 1998;116:1496-504. https://doi.org/10.1001/archopht.116.11.1496
8. Bellucci R. Multifocal intraocular lenses. Curr Opin Ophthalmol2005;16:33-7.https://doi.org/10.1097/00055735-200502000-00006
9. Johnson & Johnson Vision. Delivering intermediate vision: the new TECNIS Eyhance Monofocal IOL: Highlights from the Frankfurt January 2019 Advisory Board Meeting. 2019. Available at: https://theophthalmologist.com/subspecialties/delivering-intermediate-vision-the-new-tecnis-eyhance-monofocal-iol
10. Mencucci R, Cennamo M, Venturi D,et al. Visual outcome, optical quality, and patient satisfaction with a new monofocal IOL, enhanced for intermediate vision: preliminary results. J Cataract Refract Surg 2020;46:378-87. https://doi.org/10.1097/j.jcrs.0000000000000061
11. Kohnen T, Titke C, Böhm M. Trifocal intraocular lens implantation to treat visual demands in various distances following lens removal. Am J Ophthalmol 2016;161:71-7.e1. https://doi.org/10.1016/j.ajo.2015.09.030
12. Monaco G, Gari M, Di Censo F, et al. Visual performance after bilateral implantation of 2 new presbyopia-correcting intraocular lenses: Trifocal versus extended range of vision. J Cataract Refract Surg 2017;43:737-47. https://doi.org/10.1016/j.jcrs.2017.03.037
13. Mencucci R, Favuzza E, Caporossi O, et al. Comparative analysis of visual outcomes, reading skills, contrast sensitivity, and patient satisfaction with two models of trifocal diffractive intraocular lenses and an extended range of vision intraocular lens. Graefes Arch Clin Exp Ophthalmol 2018;256:1913-22. https://doi.org/10.1007/s00417-018-4052-3
14. Lopes D, Loureiro T, Carreira R, et al. Comparative evaluation of visual outcomes after bilateral implantation of an advanced or conventional monofocal intraocular lens. Eur J Ophthalmol 2022;32:229-34. https://doi.org/10.1177/1120672121995343
15. Kılıç A, Özpınar A, Tanrıverdi C. Comparison of visual outcomes of two trifocal IOLs. J Refract Surg 2023;39:524-30. https://doi.org/10.3928/1081597X-20230424-01
16. Ye PP, Yao K, Li X, et al. Binocular clinical comparison study of Tecnis multifocal aspheric and monofocal spherical intraocular lenses. Zhonghua Yan Ke Za Zhi 2010;46:625-30.
17. Ucar F, Cetinkaya S. The evaluation of postoperative objective and subjective refraction for premium intraocular lenses. Revista Brasileira de Oftalmologia 2020;79:386-90.
18. Richman J, Lorenzana LL, Lankaranian D, et al. Importance of visual acuity and contrast sensitivity in patients with glaucoma. Arch Ophthalmol 2010;128:1576-82. https://doi.org/10.1001/archophthalmol.2010.275
19. Jonker SM, Bauer NJ, Makhotkina NY, et al. Comparison of a trifocal intraocular lens with a +3.0 D bifocal IOL: results of a prospective randomized clinical trial. J Cataract Refract Surg 2015;41:1631-40. https://doi.org/10.1016/j.jcrs.2015.08.011
20. Pieh S, Weghaupt H, Skorpik C. Contrast sensitivity and glare disability with diffractive and refractive multifocal intraocular lenses. J Cataract Refract Surg 1998;24:659-62. https://doi.org/10.1016/s0886-3350(98)80261-7

21. Eppig T, Filser E, Goeppert H, et al. Index of contrast sensitivity (ICS) in pseudophakic eyes with different intraocular lens designs. Acta Ophthalmol 2015;93:e181-7. https://doi.org/10.1111/aos.12538

22. Alió JL, Piñero DP, Plaza-Puche AB, et al. Visual and optical performance with two different diffractive multifocal intraocular lenses compared to a monofocal lens. J Refract Surg 2011;27:570-81. https://doi.org/10.3928/1081597X-20101223-01

23. Haaskjold E, Allen ED, Burton RL, et al. Contrast sensitivity after implantation of diffractive bifocal and monofocal intraocular lenses. J Cataract Refract Surg 1998;24:653-8. https://doi.org/10.1016/s0886-3350(98)80260-5

24. Holladay JT, Piers PA, Koranyi G, et al. A new intraocular lens design to reduce spherical aberration of pseudophakic eyes. J Refract Surg 2002;18:683-91. https://doi.org/10.3928/1081-597X-20021101-04

25. Chiam PJ, Chan JH, Aggarwal RK, et al. ReSTOR intraocular lens implantation in cataract surgery: quality of vision. J Cataract Refract Surg 2006;32:1459-63. https://doi.org/10.1016/j.jcrs.2006.04.015

26. Gundersen KG, Potvin R. Trifocal intraocular lenses: a comparison of the visual performance and quality of vision provided by two different lens designs. Clin Ophthalmol 2017;11:1081-7. https://doi.org/10.2147/OPTH.S136164

27. Choi WK, Han HJ, Son HS, et al. Clinical outcomes of bilateral implantation of new generation monofocal IOL enhanced for intermediate distance and conventional monofocal IOL in a Korean population. BMC Ophthalmol 2023;23:157. https://doi.org/10.1186/s12886-023-02897-2

28. Tokko HA, Hussain F, Al-Awadi A, et al. Factors associated with the development of posterior capsule opacification requiring yttrium aluminum garnet capsulotomy. Optom Vis Sci 2019;96:492-9. https://doi.org/10.1097/OPX.0000000000001396

29. Zhao Y, Yang K, Li J, et al. Comparison of hydrophobic and hydrophilic intraocular lens in preventing posterior capsule opacification after cataract surgery: An updated meta-analysis. Medicine (Baltimore) 2017;96:e8301. https://doi.org/10.1097/MD.0000000000008301

30. Chang A, Kugelberg M. Posterior capsule opacification 9 years after phacoemulsification with a hydrophobic and a hydrophilic intraocular lens. Eur J Ophthalmol 2017;27:164-8. https://doi.org/10.5301/ejo.5000831

31. Prinz A, Neumayer T, Buehl W, et al. Rotational stability and posterior capsule opacification of a plate-haptic and an open-loop-haptic intraocular lens. J Cataract Refract Surg 2011;37:251-7. https://doi.org/10.1016/j.jcrs.2010.08.049

32. Duman R, Karel F, Özyol P, et al. Effect of four different intraocular lenses on posterior capsule opacification. Int J Ophthalmol 2015;8:118-21. https://doi.org/10.3980/j.issn.2222-3959.2015.01.22

33. Hirnschall N, Nishi Y, Crnej A, et al. Capsular bag stability and posterior capsule opacification of a plate-haptic design microincision cataract surgery intraocular lens: 3-year results of a randomised trial. Br J Ophthalmol 2013;97:1565-8. https://doi.org/10.1136/bjophthalmol-2013-303710